DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Control and Protection of Modular Uninterruptible Power Supply System

Location: Pontoppidanstræde 111, room 1.177

Time: Wednesday 16 May at 13.00

PhD defendant: Jinghang Lu

Supervisor: Professor Josep Guerrero

Moderator: Associate Professor Sanjay K. Chaudhary

Opponents: Associate Professor Tamas Kerekes, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Cassiano Rech, Universidade Federal de Santa Maria, Brazil
Associate Professor Eduardo Mojica Nava, National University of Colombia, Colombia

All are welcome. The defence will be in English.

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Abstract:
Driven by the increasing importance of the Uninterruptible Power Supply (UPS) in the industry including enterprise IT, commercial telecom, data center and cloud computing area, the global market for the On-line UPS system is projected to soar dramatically in the next few years. However, the existing products still need improvement from control and protection perspective to provide more reliable, efficient, and secure electrical power supply for the modern digital equipment. This project is to investigate the control and protection of power electronic converter for muodular UPS system.

First, a DC-link voltage protection (DCVP) control method is proposed to address the DC-link overvoltage issue due to power back-feeding in parallel Uninterruptible Power Supply (UPS) system. The proposed control method is able to protect the inverter against the excessive DC-link voltage, which increases the system reliability and robustness. Moreover, a current sharing control strategy is proposed by online regulating the virtual resistance of each UPS module. The proposed current sharing control strategy is able to address the circulating fundamental and harmonic current caused by the line impedance mismatching or power back-feeding issue in the UPS system. In addition, an improved consensus-based distributed controller is proposed to alleviate the overshoot issue during the transient process in voltage amplitude and frequency restoration.

In addtion, To enhance the robustness and disturbance rejection ability of an on-line uninterruptible power supply (UPS) system, an Internal Model Control (IMC) based DC-link voltage regulation method is proposed. To further enhance the ability of DC link control, an enhanced state observer (ESO)-based controller is presented for control the AC/DC converter of the UPS system. The proposed controller, contrary to the traditional ones, does not require the DC-link current measurement and offers a “plug and play” capability, a rather high disturbance rejection ability and robustness against the DC-link capacitance parameter variation. The design procedure of the suggested controller is discussed as well.

Furthermore, the multi-mode operations of the on-line UPS system are investigated and their corresponding control strategies are proposed. The proposed control strategies are capable of achieving the seamless transition in traditional Normal mode, PV-aided Normal mode, Enhanced Eco-mode and Burn-in test mode. Meanwhile, the uninterruptible load voltage is promised during the mode transition. The small signal analysis is also conducted to investigate the stability of enhanced eco-mode and burn-in test mode. Finally, extensive experimental results are provided to validate the effectiveness of the proposed methods.

Morover, the disturbance rejection performance of the cascaded control strategy for UPS system is investigated. The comparison of closed loop system performance between conventional cascaded control (CCC) strategy and state-decoupling cascaded control (SDCC) strategy are further explored. In order to further increase the load current disturbance rejection capability of the state-decoupling in UPS system, a feedforward control strategy is proposed. In addition, the design principle for the current and voltage regulators are discussed.

Consequently, in order to verify the effectiveness and the performance of the proposed control strategies, experiments on a multi-three-phase inverter-based platform are implemented. The experimental results demonstrates the effectiveness of the proposed control strategies in real implementation.

Key words: Uninterruptible Power Supply, parallel inverters, Virtual resistance, Multi-mode operation. Enhanced Eco-mode, Burn-in test mode, Enhanced State observer, droop control.